BIOSPHERE

Implications of cosmic rays and solar UV-radiation for Earth's biosphere

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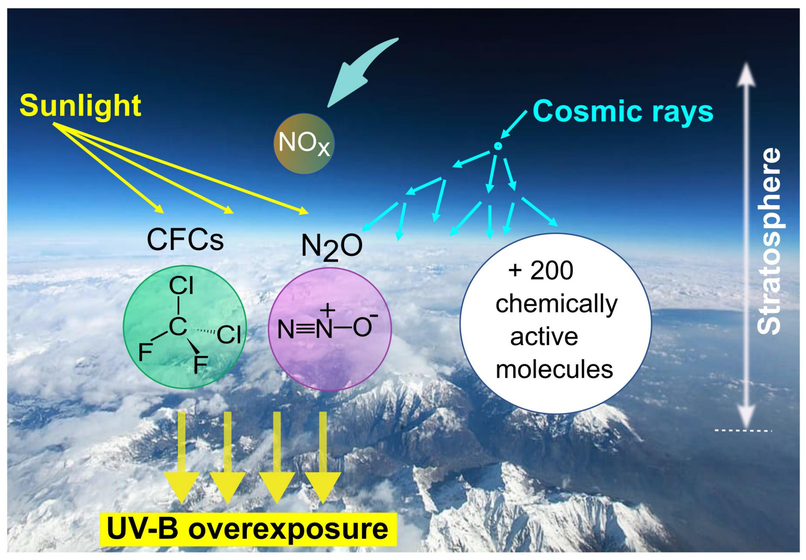
on behalf of 21GRD02 BIOSPHERE Consortium (Project start: 01.10.2022; Project end: 30.09.2025)

The project 21GRD02 BIOSPHERE has received funding from the European Partnership on Metrology, co-financed by the European Union's Horizon Europe Research and Innovation Programme and by the Participating States.

Need

The increasing atmospheric ionisation caused by extra-terrestrial radiation (cosmic rays and solar UV radiation) boosted by anthropogenic emissions can significantly affect the Earth biosphere by depleting the ozone layer. This leads to an increase of the biologically active UV radiation flux, with significant implication for human health, plants and marine ecosystems.

While ionization of chlorine-containing anthropogenic molecules by solar UV radiation has long been recognized as an explanation for ozone depletion in the stratosphere, the role of cosmic rays and, in particular, low-energy electrons remain largely unexplained. The effects of combined cosmic and UV radiation fields on biological systems are also not fully explored.



There is an urgent need to combine observations by modern satellite technologies and ground-based monitoring systems with scientific expertise in biology, chemistry, environment, and radiation protection to study how increased atmospheric ionization affects the evolution of the biosphere and impacts our health status. **Research is needed to:**

- identify and quantify the relationship between cosmic radiation, ozone depletion and anthropogenic emission,
- quantify the interaction cross sections of cosmic ray-induced electrons with molecules relevant in stratospheric chemistry and ozone depletion,
- assess the impact of combined SCR and UV irradiation on human health.

Operational capacity

To develop metrological methods capable of identifying and establishing correlations between cosmic rays, solar UV radiation, and thickness of the ozone layer, and to assess their mutual effects on biological systems, the BIOSPHERE consortium has access to groundbreaking operational capabilities:

On-ground cosmic ray detectors, UV spectroradiometers, LIDAR(s)

Muon detectors, neutron detectors, semiconductor spectrometers (Timepix3), UV spectroradiometer (BTS-Solar), UVB pyranometers, LIDARs.

Satellite observations of energetic electron and proton fluxes, and traceable absolute solar UV irradiance data

Access to PROBA-V satellite, GOES satellite, Total and Spectral solar Irradiance Sensor (TSIS) onboard of the ISS.

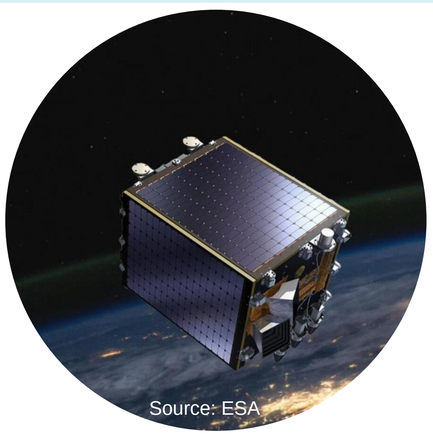
Instruments to measure the cross sections for ionization, dissociative electron attachment, and fragmentation-ion production.

Reaction microscopes, hemispherical electron energy analyzers and reflectron TOF mass spectrometry.

Investigation of structural and functional damages in human primary cells inflicted by combined cosmic and UV exposure

Transmission electron microscopy, cellular tomography, atomic force microscopy, irradiations at accelerator facilities, experiments at underground laboratories.


Source: ESA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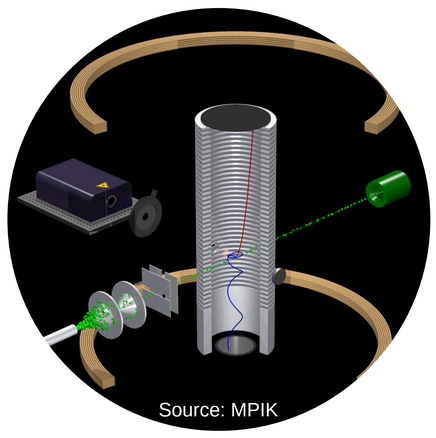
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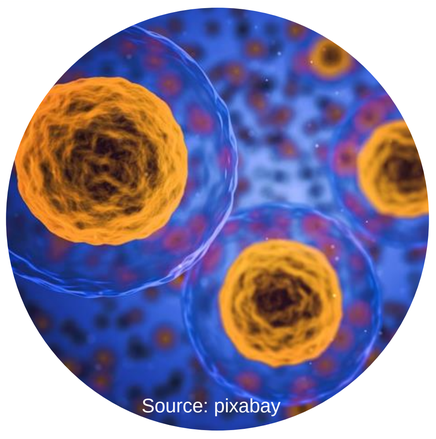
Source: pixabay

Technical work packages

WP1: Characterization and adaption of instrumentation for determining the dependence of secondary cosmic rays (SCR) on primary cosmic rays (galactic cosmic rays, solar particle events) and atmospheric parameters (e.g., temperature, density and aerosol concentration).

This instrumentation will measure the SCR flux rate in WP2, side-by-side with terrestrial solar UV spectrum and total atmospheric ozone, with the goal of correlating them.

WP2: Development of a metrological methodology to identify and quantify the relationship between cosmic radiation, UV radiation and anthropogenic emission.

Traceable measurement of cosmic ray fluxes, UV radiation spectrum and ozone column will be carried out at 4 European sites.

4 Measurement campaigns, 3 months each

Germany · Belgium · Greece · Czech Republic

WP3: Quantification of molecular processes involving low-energy electrons that affect ozone depletion and atmospheric dynamics.

For the first time, fundamental data on the interaction of low-energy electrons with atmospheric gases of both natural and anthropogenic origin will be provided. These include cross sections for ionization, dissociative electron attachment and fragmentation-ion production of atmospheric constituents (at least 4) such as N_2, O_2, NO, NO_2, selected chlorofluorocarbons (CFCs), halogenated molecules (such as HCl, HF, HBr), SF_6 as well as aromatic and nitrogenated molecules (such as pyridines whose cations facilitate aerosol formation) under electron impact with energies from < 10 eV – 2000 eV.

WP4: Assessing the impact of combined SCR and UV irradiation on human health by determining the effect of mixed radiation fields on normal human cell lines.

Three human cell lines (including primary cells) will be used: 1) Lung and primary skin fibroblasts, 2) Brain cerebral microvascular endothelial and normal epithelial cells and 3) Healthy blood monocytes. Correlations between radiation type and flux, and changes to cellular parameters (cell death, DNA damage and genomic instability, adhesion, and proliferation) will be established. In addition, the expression profile of stress genes will be determined using established radiation effect models and systems biology approaches.

Impact

Traceable data will help investigate the contribution of combined SCR and UV radiation fields in the risk for developing chronic diseases and cancer. Radiobiology / radio-oncology researchers, health groups and regulatory bodies will profit from the research data.

This project will create for a first time a comprehensive database of collision cross sections for natural atmospheric and anthropogenic gases. The database will be in an open format and can be used by modellers, developers and users from NMIs, public health and environmental agencies, research institutions focusing on the environment, climate, medicine and biology, and radiation protection and equipment manufacturers.

The data and methods resulting from the project will be useful for ecological correlative studies, providing insight into unexplored interactions between SCR and UV radiation fields, stratospheric ozone, the environment, and human health.

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